

AMENDMENTS TO THE CLAIMS

This listing of claims will replace all prior versions, and listings, of claims in the application:

Listing of Claims:

- 1 1. (Currently amended) A method for measuring alignment between a first
2 semiconductor die and a second semiconductor die, comprising:
3 applying a pattern of voltage signals to a two-dimensional array of
4 conductive transmitter elements that form a transmitter array on the first
5 semiconductor die;
6 wherein the transmitter array on the first semiconductor die is located over
7 a corresponding two-dimensional array of conductive receiver elements that form
8 a receiver array on the second semiconductor die;
9 wherein transmitter elements have a different spacing than receiver
10 elements, whereby a two-dimensional vernier alignment structure is created when
11 the transmitter array is located over the receiver array;
12 wherein a voltage signal applied to a transmitter element induces a voltage
13 signal in one or more receiver elements;
14 amplifying voltage signals induced in receiver elements in the receiver
15 array; and
16 analyzing the amplified signals to determine an alignment between the
17 first semiconductor die and the second semiconductor die.

- 1 2 (Canceled).

- 1 3. (Original) The method of claim 1,

2 wherein the transmitter array is organized as a two-dimensional $n \times m$ grid
3 including nm conductive elements; and
4 wherein the receiver array includes at least three conductive elements
5 which are not collinear.

1 4. (Original) The method of claim 1,
2 wherein the receiver array is organized as a two-dimensional $n \times m$ grid
3 including nm conductive elements; and
4 wherein the transmitter array includes at least three conductive elements
5 which are not collinear.

1 5. (Original) The method of claim 1, wherein determining the alignment
2 involves determining six degrees of alignment, including:
3 an x alignment parallel to plane of the receiver array;
4 a y alignment parallel to plane of the receiver array and normal to the x
5 axis;
6 a z alignment normal to the plane of the receiver array;
7 an angular alignment, θ , about the z axis;
8 an angular alignment, Ψ , about the y axis; and
9 an angular alignment, Φ , about the x axis.

1 6. (Original) The method of claim 5, wherein determining the alignment
2 involves analyzing coupling capacitances between individual receiver elements
3 and individual transmitter elements to determine the x alignment, the y alignment
4 and the angular alignment, θ .

1 7. (Original) The method of claim 6, wherein analyzing the coupling
2 capacitances involves determining a nearest neighbor mapping between receiver
3 elements and transmitter elements.

1 8. (Original) The method of claim 5, wherein determining the alignment
2 involves using a mapping function generated by a three-dimensional capacitance
3 field solver simulation to determine the z alignment, the angular alignment, Ψ , and
4 the angular alignment, Φ .

1 9. (Original) The method of claim 5, wherein determining the z alignment,
2 the angular alignment, Ψ , and the angular alignment, Φ , involves summing
3 capacitances between individual receiver elements in the receiver array and all
4 transmitter elements in the transmitter array, thereby effectively considering the
5 transmitter array to be one large plate.

1 10. (Original) The method of claim 5, wherein determining the z
2 alignment, the angular alignment, Ψ , and the angular alignment, Φ , involves
3 summing capacitances between individual transmitter elements in the transmitter
4 array and all receiver elements in the receiver array, thereby effectively
5 considering the receiver array to be one large plate.

1 11. (Original) The method of claim 1, further comprising electrically
2 varying the pitch of the transmitter array by grouping together adjacent transmitter
3 elements.

1 12. (Original) The method of claim 1, further comprising electrically
2 varying the pitch of the receiver array by grouping together adjacent receiver
3 elements.

1 13. (Original) The method of claim 1, wherein transmitter elements and
2 receiver elements are:

3 square;
4 rectangular;
5 hexagonal;
6 triangular;
7 oval; or
8 round.

1 14. (Original) The method of claim 1,
2 wherein transmitter elements are located in a metal layer of the first
3 semiconductor die and are not covered by higher layers of metal; and
4 wherein receiver elements are located in a metal layer of the second
5 semiconductor die and are not covered by higher layers of metal.

1 15. (Currently amended) An apparatus that measures alignment between a
2 first semiconductor die and a second semiconductor die, comprising:

3 a two-dimensional array of conductive transmitter elements that form a
4 transmitter array on the first semiconductor die;

5 a two-dimensional array of conductive receiver elements that form a
6 receiver array on the second semiconductor die;;

7 wherein transmitter elements have a different spacing than receiver
8 elements, whereby a two-dimensional vernier alignment structure is created when
9 the transmitter array is located over the receiver array;

10 a driving mechanism configured to apply a pattern of voltage signals to the
11 transmitter array;

12 wherein a voltage signal applied to a transmitter element induces a voltage
13 signal in one or more receiver elements when the transmitter array is located over
14 the receiver array;

15 an amplification mechanism configured to amplify voltage signals induced
16 in receiver elements in the receiver array; and

17 an analysis mechanism configured to analyze the amplified signals to
18 determine an alignment between the first semiconductor die and the second
19 semiconductor die.

1 16 (Canceled).

1 17. (Original) The apparatus of claim 15,
2 wherein the transmitter array is organized as a two-dimensional $n \times m$ grid
3 including nm conductive elements; and
4 wherein the receiver array includes at least three conductive elements
5 which are not collinear.

1 18. (Original) The apparatus of claim 15,
2 wherein the receiver array is organized as a two-dimensional $n \times m$ grid
3 including nm conductive elements; and
4 wherein the transmitter array includes at least three conductive elements
5 which are not collinear.

1 19. (Original) The apparatus of claim 15, wherein the driving mechanism
2 and the analysis mechanism are configured to determine six degrees of alignment,
3 including:
4 an x alignment parallel to plane of the receiver array;

5 a y alignment parallel to plane of the receiver array and normal to the x
6 axis;
7 a z alignment normal to the plane of the receiver array;
8 an angular alignment, θ , about the z axis;
9 an angular alignment, Ψ , about the y axis; and
10 an angular alignment, Φ , about the x axis.

1 20. (Original) The apparatus of claim 19, wherein the analysis mechanism
2 is configured to determine coupling capacitances between individual receiver
3 elements and individual transmitter elements to determine the x alignment, the y
4 alignment and the angular alignment, θ .

1 21. (Original) The apparatus of claim 20, wherein the analysis mechanism
2 is configured to determine a nearest neighbor mapping between receiver elements
3 and transmitter elements.

1 22. (Original) The apparatus of claim 19, wherein the analysis mechanism
2 is configured to use a mapping function generated by a three-dimensional
3 capacitance field solver simulation to determine the z alignment, the angular
4 alignment, Ψ , and the angular alignment, Φ .

1 23. (Original) The apparatus of claim 19, wherein the apparatus is
2 configured to determine the z alignment, the angular alignment, Ψ , and the angular
3 alignment, Φ , by summing capacitances between individual receiver elements in
4 the receiver array and all transmitter elements in the transmitter array, thereby
5 effectively considering the transmitter array to be one large plate.

1 24. (Original) The apparatus of claim 19, wherein the apparatus is
2 configured to determine the z alignment, the angular alignment, Ψ , and the angular
3 alignment, Φ , by summing capacitances between individual transmitter elements
4 in the transmitter array and all receiver elements in the receiver array, thereby
5 effectively considering the receiver array to be one large plate.

1 25. (Original) The apparatus of claim 15, wherein the apparatus is
2 configured to electrically vary the pitch of the transmitter array by grouping
3 together adjacent transmitter elements.

1 26. (Original) The apparatus of claim 15, wherein the apparatus is
2 configured to electrically vary the pitch of the receiver array by grouping together
3 adjacent receiver elements.

1 27. (Original) The apparatus of claim 15, wherein transmitter elements and
2 receiver elements are:

3 square;
4 rectangular;
5 hexagonal;
6 triangular;
7 oval; or
8 round.

1 28. (Original) The apparatus of claim 15,
2 wherein transmitter elements are located in a metal layer of the first
3 semiconductor die and are not covered by higher layers of metal; and
4 wherein receiver elements are located in a metal layer of the second
5 semiconductor die and are not covered by higher layers of metal.